

CR-134131

E-2795

MISSION SL-4 (AS 208/CM 118/IMU 34)

G&N ERROR ANALYSIS

(SKYLAB 4)

by

S. B. HELFANT

October 1973

(NASA-CR-134131) MISSION SL-4 (AS 208/CM
118/IMU 34) G AND N ERROR ANALYSIS
(SKYLAB 4) (Draper (Charles Stark) Lab.,
Inc.) 33 p HC \$3.75

CSCL 22C

N74-12504

Unclas

G3/31 22831



The Charles Stark Draper Laboratory, Inc.
Cambridge, Massachusetts 02139

E-2795

MISSION SL-4 (AS 208/CM 118/IMU 34)

G&N ERROR ANALYSIS

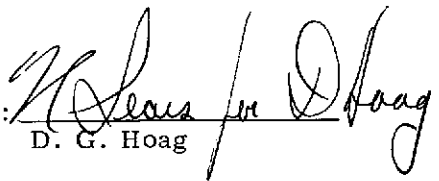
(SKYLAB 4)

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CAMBRIDGE, MASSACHUSETTS 02139

Approved: 

D. G. Hoag

ACKNOWLEDGMENT

This report was prepared by the Charles Stark Draper Laboratory under Contract NAS 9-4065 with the L. B. Johnson Space Center of the National Aeronautics and Space Administration.

The author wishes to acknowledge the contributions made to this report by Julius Feldman. Mr. Feldman helped in the review of this and previous reports and many of his suggestions have been included.

This volume is the combined effort of the following additional people: Linda Willy prepared the component performance tabulation and performed the plotting for the inertial components. William Beaton provided the failure rates for the success probability. Their contribution to the preparation of this volume is greatly appreciated.

The publication of this report does not constitute approval by the National Aeronautics and Space Administration of the findings or the conclusions contained herein. It is published only for the exchange and stimulation of ideas.

E-2795

MISSION SL-4 (AS 208/CM 118/IMU 34)
G&N ERROR ANALYSIS
(SKYLAB 4)

ABSTRACT

This document presents data on G&N system performance and operation for the CM. For data on the effects of Block II and of measured CM IMU test data deviation uncertainties on earth orbit insertion indication uncertainties and on deorbit burn and reentry uncertainties, the reader is referred to E-2760, the G&N error analysis report for Skylab 2).

by: S.B. Helfant
October 1973

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GYRO DRIFT TEST POSITIONS
FOR
SUNDANCE, LUMINARY, COLOSSUS, AND ON

STABLE MEMBER POSITION	STABLE MEMBER ORIENTATION	HORIZONTAL DRIFT	VERTICAL DRIFT
1	X DOWN Y SOUTH Z WEST	NBDY-ADOAY	
2	X DOWN Y WEST Z NORTH	+NBDZ-ADOAZ	-NBDZ+ADIAX
3	X SOUTH Y WEST Z DOWN	NBDX-ADOAX	
4	X EAST Y SOUTH Z DOWN	+NBDY+ADSRAY	+NBDZ+ADIAZ
5*	X WEST Y UP Z NORTH	+NBDZ-ADSRAZ	
6*	X SOUTH Y DOWN Z EAST	+NBDX+ADSRAZ	-NBDY+ADIAY
7	X NORTH Y UP-WEST Z UP-EAST	$-NBDX + (ADSRAZ / \sqrt{2})$	
8	X EAST Y UP-NORTH Z UP-SOUTH	$(-NBDZ - NBDY) / \sqrt{2}$ $+(ADIAZ - ADIAY) / 2$ $+(ADSRAY + ADSRAZ) / 2$	
9	X UP-EAST Y UP-WEST Z SOUTH	$-NBDZ + (ADSRAZ / \sqrt{2})$	
10	X UP-NORTH Y UP-SOUTH Z EAST	$(NBDY - NBDX) / \sqrt{2}$ $+(ADIAY - ADIAX) / 2$ $+ADSRAZ / 2$	
11	X NORTH Y WEST Z UP	-NBDX-ADOAX	
12	X UP Y SOUTH Z EAST	+NBDY+ADOAY	
13	X UP Y EAST Z NORTH	+NBDZ+ADOAZ	

* Positions 5 and 6 are lab test only.

SKYLAB 4

G&N MISSION RELIABILITY ANALYSIS

Failure rates used were obtained, for the most part, from observed Apollo field and flight experience of the PGNS. Each reported failure was analyzed with respect to its likelihood of occurrence in flight and the impact on the Mission should such failure occur. The result was to count only those reported failures which could occur in flight and which would degrade the Mission, should they occur.

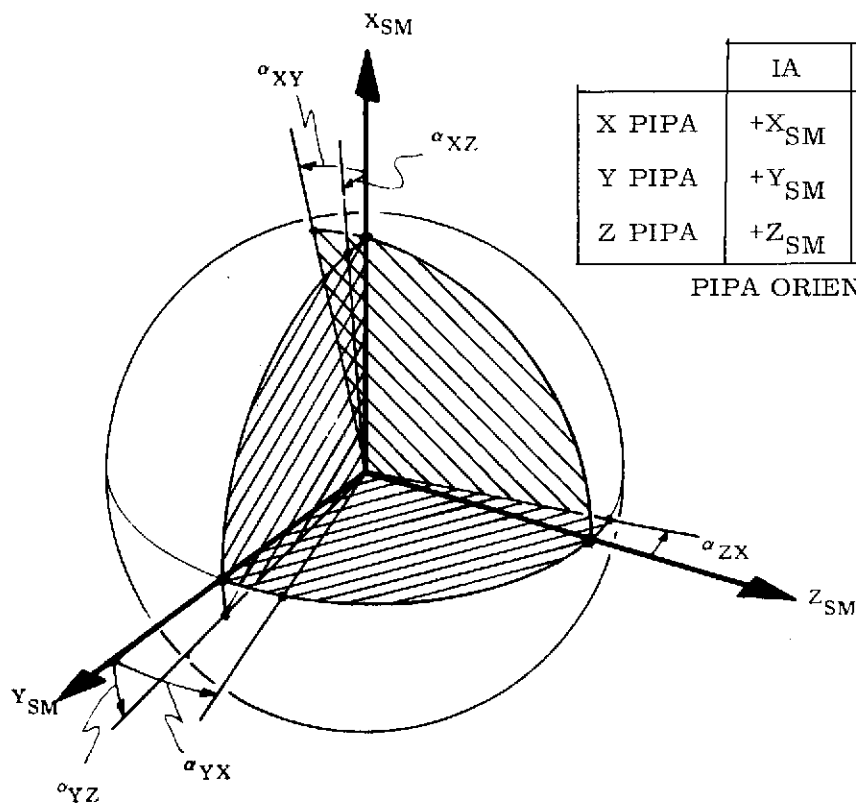
SUBSYSTEM	MODE (time/cycles)	FAILURE RATE ($\lambda \times 10^6$)	MISSION DURATION (hrs or cycles)	$e^{-\lambda t}$
AGC	Operate	19.2	61	0.99883
	Calendar	2.8	1728	0.99517
	Envirn	30.9	0.45	0.99999
	On/Off	238.1	2	0.99952
DSKY*	Operate	1.4	61	0.99999
	Calendar	0.9	1728	0.99999
	Envirn.	122.9	0.45	0.99999
	On/Off	1190.5	2	0.99999
IMU CDU**	Operate	20.2	61	0.99877
	Calendar	2.4	1728	0.99586
	Envirn	62.5	0.45	0.99997
	On/Off	1666.6	2	0.99667
IMU	Operate	94.1	61	0.99428
	Calendar	2.6	1728	0.99552
	Envirn	18.5	0.45	0.99999
	On/Off	142.9	2	0.99971
IMU Electronics (PSA)	Operate	8.4	61	0.99949
	Calendar	1.2	1728	0.99793
	Envirn	18.5	0.45	0.99999
	On/Off	714.3	2	0.99857
Optics Assembly	Operate	119.3	61	0.99275
	Calendar	1.8	1728	0.99689
	Envirn	18.5	0.45	0.99999
	On/Off	238.1	2	0.99952
Optics Electronics	Operate	17.2	61	0.99895
	Calendar	7.1	1728	0.98781
	Envirn	18.5	0.45	0.99999
	On/Off	142.9	2	0.99971

G&N MISSION RELIABILITY

CM = 0.94712

*Considers parallel redundancy $(1 - (1 - e^{-\lambda t})^2)$

**Includes CM Optics CDU



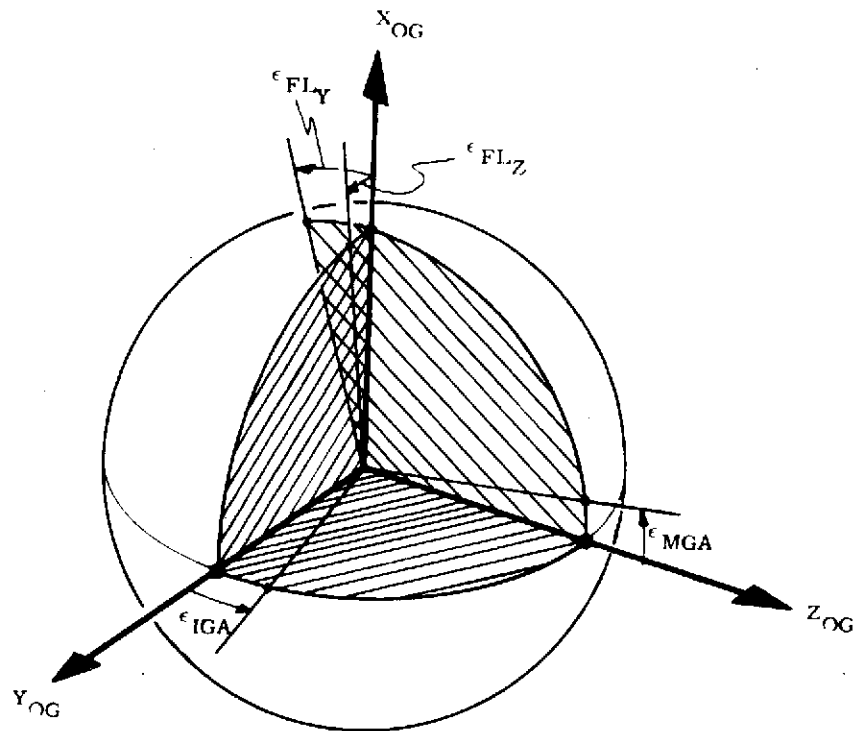
	IA	OA	PRA
X PIPA	$+X_{SM}$	$+Z_{SM}$	$-Y_{SM}$
Y PIPA	$+Y_{SM}$	$-Z_{SM}$	$+X_{SM}$
Z PIPA	$+Z_{SM}$	$+X_{SM}$	$-Y_{SM}$

PIPA ORIENTATIONS

PIPA Misalignments from Ideal Stable Member Axes

Term	(Angle in $\widehat{\text{Sec}}$) CM-IMU 34
α_{XY}	- 7
α_{XZ}	-19
α_{YZ}	+ 5
α_{YX}	+26
α_{ZX}	-17

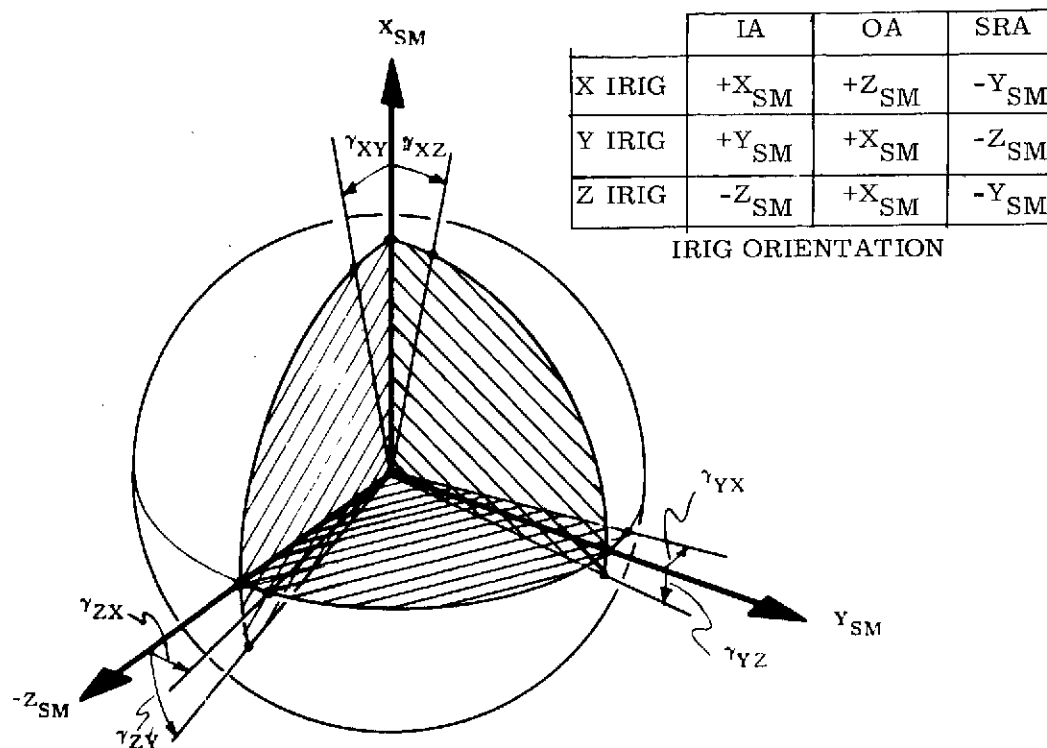
DEFINITION OF POSITIVE SENSE
PIPA INPUT-AXIS MISALIGNMENTS
with respect to
IDEAL STABLE MEMBER AXES



Gimbal Axis Orthogonality Errors and Outer Gimbal Misalignment from Casemounting Axes

Term	(Angle in Sec)
	CM-IMU 34
ϵ_{IGA}	0
ϵ_{MGA}	- 6
ϵ_{FLY}	0
ϵ_{FLZ}	+ 1

DEFINITION OF POSITIVE SENSE
 GIMBAL AXIS ORTHOGONALITY
 and
 OUTER GIMBAL ALIGNMENT
 with respect to
 CASE MOUNTING ALIGNMENT



IRIG Misalignments from Ideal Stable Member Axes

Term	(Angle in Sec)
	CM-IMU 34
γ_{XY}	- 4
γ_{XZ}	-28
γ_{YZ}	- 8
γ_{YX}	-22
γ_{ZX}	+ 9
γ_{ZY}	+ 7

Block II G&N
 DEFINITION OF POSITIVE SENSE
 IRIG INPUT-AXIS MISALIGNMENTS
 with respect to
 IDEAL STABLE MEMBER AXES

IMU S/N 34
AS208/CM 118/G&N 222

IRIGs

X = 8A117

Y = 8A102

Z = 8A101

PIPAs

X = 3AP333

Y = 3AP334

Z = 3AP335

8A-117 CONTINUED

NASA 8A-117

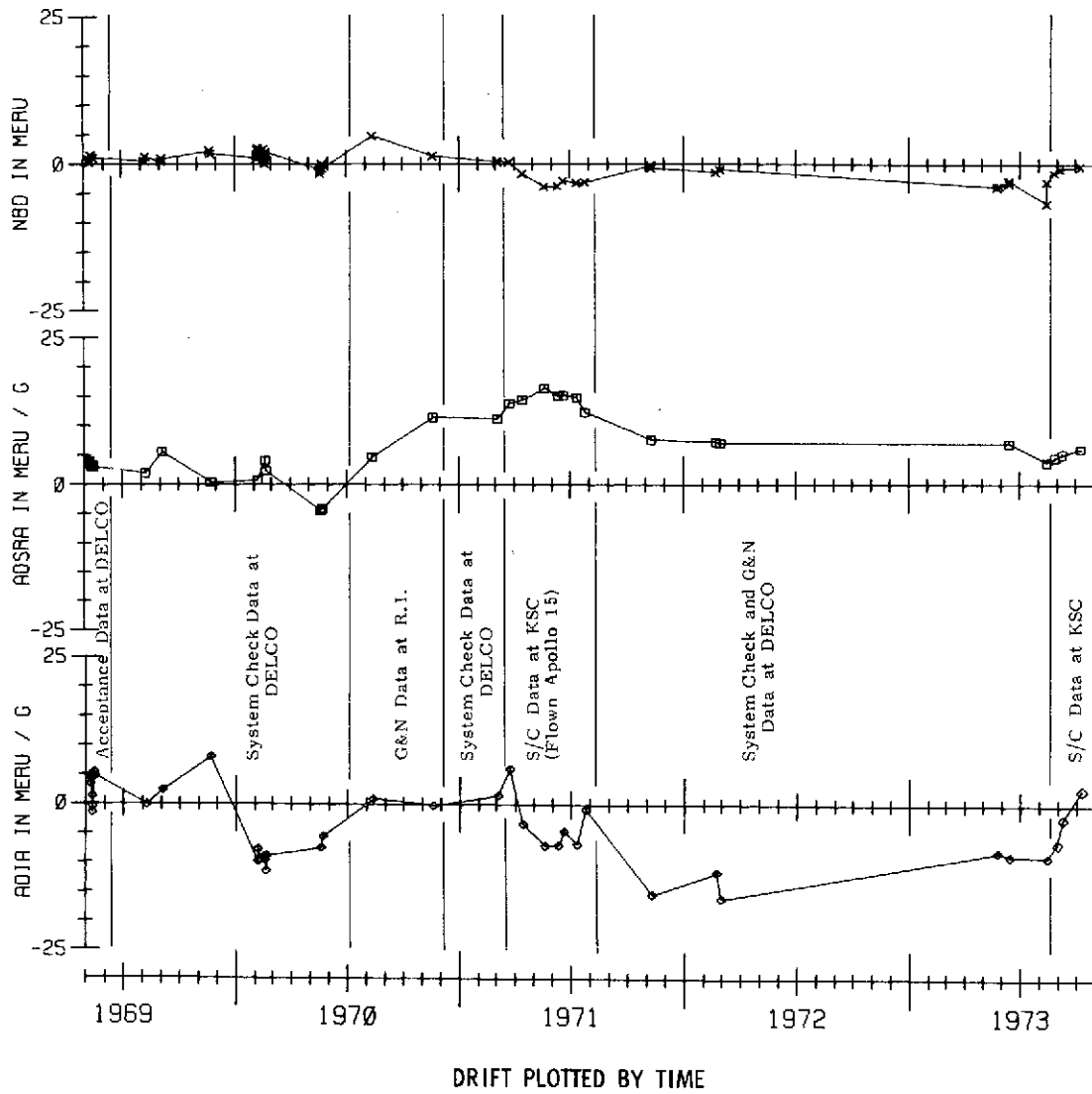
DATE	LOC	TST IMU	GEN	ADSPA	ADTA	DELSP+	DELSP-	WHEEL	T+	I-	ID	ACOA	
		TYP	ASSEN	SYS	NBR			PDT	HOURS				
17FE70	A03	SCK	Y	48	1.3	-	9.5						
18FE70	DATA AFTER OVERNIGHT STORAGE WITH Y CA UP FOLLOWS.												
18FE70	A03	SCK	Y	48	0.0	4.1						1.3	
18FE70	A03	SCK	Y	48	0.7	-	11.4						
19FE70	DATA AFTER OVERNIGHT STORAGE WITH Y IA DOWN FOLLOWS.												
19FE70	A03	SCK	Y	48	1.5	2.3						1.3	
19FE70	A03	SCK	Y	48	1.9	-	8.8		811				
16MP70	IMU	S/N	48	SHIPPED FROM AC/MKE TO KSC.									
12MY70	IMU	S/N	48	SHIPPED FROM KSC TO AC/MKE.									
19MY70	A03	SPO	Y	48	-	1.1	-	7.4					
19MY70	A03	SPO	Y	48	-	1.7	-	4.5		C113		1.1	
22MY70	A03	SPO	Y	48	-	0.1	-	5.5					
22MY70	A03	SPO	Y	48	-	0.8	-	4.2				1.1	
25MY70	A03	SPO	Y	48				- 294 - 674	916	55.003			
27MY70	NO FLUID TRANSIENTS APPARENT DURING GRAVITY TRANSIENT TEST.												
7JL70	IMU	S/N	48	SHIPPED FROM AC/MKE TO NR.									
13JL70	IMU	S/N	48	INSTALLED IN CM-112 (GEN 217).									
11AU70	NSC	GEN	Y	48	217	4.7	4.7	0.9	15	-	485		
11AU70	ADIAI POSITION 8												
31AU70	NSC	GEN	Y	48	217						990		
31OC70	NSC	GEN	Y	48	217						995		
18NO70	NSC	GEN	Y	48	217	1.3	11.4	-	0.2	130	-	348	
18NO70	ADIAI POSITION 8												
7DE70													
9DE70	IMU	S/N	48	SHIPPED FROM NR TO DELCO/MKE.									
28FE71													
4MR71	A03	SPO	Y	48	0.3		1.6						
4MR71	A03	SPO	Y	48	0.5	11.2							
5MR71	A03	SPO	Y	48				- 160 - 407		85.016		1.6	
7MR71	NO FLUID TRANSIENTS DETECTED DURING GRAVITY TRANSIENT TEST.												
8MR71													
8MR71	IMU	S/N	48	SHIPPED FROM DELCO/MKE TO KSC.									
19MR71	IMU	48	GEN	217	INSTALLED IN CM-112.								
23MR71	KOB	GEN	Y	48	217	0.3	13.8	6.1	-	195	-	200	
23MR71	ADIAI POSITION 8												
31MR71	KOB	GEN	Y	48				1.1				1.1	
13AP71	KOB	GEN	Y	48	217	-	1.7	14.4	-	3.3	172	-	114
13AP71	ADIAI POSITION 8												
30AP71								1.5					
19MY71	K9A	GEN	Y	48	217	-	3.9	16.4	-	7.0		1341	
19MY71	ADIAI POSITION 8												
31MY71	K9A	GEN	Y	48				-	1.0			1.2	
10JE71	K9A	GEN	Y	48	217	-	3.8	15.1	-	6.9			
10JE71	ADIAI POSITION 8												
19JE71	K9A	GEN	Y	48	217	-	2.9	15.2	-	4.5		1.1	
19JE71	ADIAI POSITION 8												
30JE71	K9A	GEN	Y	48				-	1.6			1.2	
11JL71	K9A	GEN	Y	48	217	-	3.2	14.8	-	6.8	1521		
11JL71	ADIAI POSITION 8												
								-	0.3			1.0	

8A-117 CONTINUED

NASA BA-117

DATE	LOC	TST	IMU	GEN	ASSN	SYS	NBD	ADSEA	ADIA	DELST+	DELST-	WHEPI	FDI	HOURS	I+	I-	YD	ADOA
24JL71	K9A	GEN	Y	48	217	-	3.1	12.3	-	0.7								1.0
24JL71	ADIAZ	POSITION							-	4.8								
24JL71	PRE-LAUNCH	COMPENSATIONS					NBD -2.8	ATSPA 15.0	ADIA -5.0									
27JL71	NBD	VALUE	INCORPORATED				AT 27 HRS 52 MIN	GFT -1.8										
26JL71	K9A	GEN	Y	48										1671				
26JL71	IMU	48	GEN	217	CM-112		LAUNCHED.	APOLLO 15.										
7AU71	IMU	48	GEN	217	CM-112		RECOVERED											
7AU71														1966				
15OC71	IMU	48	SHIPPED				FROM NR TO DELCO/MKS.											
9NO71	A04	SPO	Y	48		-	3.2		-	15.3								
9NO71	A04	SPO	Y	48		-	0.7	7.6										1.7
10NO71	A04	SPO	Y	48								81 - 274		85.004				
19NC71	NO	FLUID	TRANSIENTS				DETECTED DURING GRAVITY TRANSIENT TEST.											
22FF72	ALC	GEN	Y	48		-	1.5	7.2	-	11.5								1.2
29FE72	ALC	GEN	Y	48		-	1.0	7.0	-	16.0				2246				1.5
4MY73	UNIT	ASSIGNED					TO IMU-34, X-POSITION REPLACING BA141.											
25MY73	SB6	SPO	Y	34		-	3.9		-	8.0		C113						
29MY73	SB6	SPO	X	34		-	3.7	8	-	8 - 13	C112		85.000					1.7
13JE73	SB6	SPO	X	34		-	3.2		-	9.7								
13JE73	SB6	SPO	X	34		-	2.8	7.0										1.6
15JE73	10	MEMO	TRANSIENT				OBSERVED DURING GRAVITY TEST.											
30JE73														2385				
10AU73	SB6	SPO	X	34							111 - 269		84.998					
14AU73	SB6	SPO	X	34		-	6.7		-	8.9		C113						
14AU73	SB6	SPO	X	34		-	3.0	3.8										
21AU73	IMU-34	SHIPPED					FROM DELCO TO KSC.											
24AU73	IMU-34	INSTALLED					IN CM-118 (SKYLAB-4).											
28AU73	K9B	GEN	X	34	222	-	1.8	4.2	-	6.7								2.6
4SE73	K9B	GEN	X	34	222	-	1.5	4.8	-	1.8								2.5
10OC73	K9B	GEN	X	34	222	-	0.8	5.3	-	1.8								2.5

G&N 222, CM 118, IMU 34, APOLLO IRIG 8A117, X AXIS



MASA 8A-102

DATE	LOC	TST TYP	GEN ASSN	SYS	NBD	ADSPA	ADIA	DELSF+	DELSF-	WHEEL PDT HOURS	I+	I-	ID	ADDA
3NO68	SG	83.6, 70.2, 56.2	TG	58.4, 70.9, 86.6						REF H5201				
4NO68	A42	CSS								C103				
4NO68	A42	CSS			(- 4.5)	(1.7)	(2.3)			C102			-15.2	
11NO68	A45	CSS			(- 5.9)	(- 0.3)	(- 6.1)			148			-16.6	
14NO68	A45	CSS			(- 5.6)	(- 0.3)	(- 5.4)			141			-15.9	
19NO68	COMP.	SELECT												
19NO68	A44	CSS						417	112	133	85.005	85.006		
20NO68	A44	CSS								142				
20NO68	A44	CSS								146				
26NO68	COMP	VERIF	TM + OOS											
26NO68	A44	CSS						- 725	160		85.002	85.004		
26NO68	DEMO	T/F = 1213												
26NO68	A44	CSS						- 225		152	84.997	84.997		
27NO68	A44	CSS								141				
4DE68	VIB	IA ALIGN = +0.1												
5DE68	A44	CA1			- 2.1	- 1.5	- 9.4							
5DE68	A44	CA2			- 2.6	- 1.0	- 9.0	+ 62	95		84.998	84.998	-16.6	
5DE68	A44	CA3			- 2.2	- 0.9	- 10.5			149				
8DE68	A44	CB1			- 1.9	- 1.3	- 10.6							
8DE68	A44	CB2			- 1.9	- 1.3	- 10.6	- 111	341	146	84.997	84.997	-17.7	
8DE68	A44	CB3			- 1.9	- 1.5	- 9.1							
10DE68	A44	CC1			- 0.6	- 2.7	- 8.7							
10DE68	A44	CC2			- 1.7	- 2.7	- 7.4	- 159	163		84.997	84.997	-15.8	
10DE68	A44	CC3			- 1.8	- 2.8	- 5.9			150				
11DE68	A42	CRT								137				
12DE68	A44	CRT								153	514			
14JA69	ACCEPTED ON WAIVER	PER C1241, C1234 & R1412												
	UNIT INSTALLED IN	IMU S/N 39Y, REPLACING 7A-200												
28JA69	A17	SPO Y 39			0.6	0.7	- 284	217			85.006		1.6	
28JA69	A17	SPO Y 39			1.0	- 7.9								
30JA69	A17	SCK Y 39			- 0.4	- 0.1	- 8.7						1.3	
30JA69	A17	SCK Y 39			- 0.4	- 8.6	- 264	148			604			
10FE69	A17	GEN Y 39			- 2.1	- 0.6	- 8.6							
10FE69	A17	GEN Y 39			- 1.3									
10FE69	A17	GEN Y 39			- 1.5						659			
26FE69	IMU	S/N 39 SHIPPED TO GAEC												
6MR69	G20	GEN Y 39 613			- 1.5	- 0.6	- 5.6	- 333	206		684			
23MY69	G20	GEN Y 39 613			- 2.8	- 5.6	- 17.6	- 249	208		694			
13AU69	GSC	GEN Y 39 613			- 3.7	- 1.1	0.2	- 119	198					
13AT69	GSC	GEN Y 39 613			- 4.9		4.6							
13AU69	GSC	GEN Y 39 613			- 5.1		9.5				756			
13AU69	POSITION B	ADIA = -10.66												
25OC69	GSC	GEN Y 39 613			- 5.7	- 0.7	- 0.7	- 142	160		823			
25OC69	ADIA	POSITION B = -10.6												
3DE69	GSC	GEN Y 39 613			- 4.4	- 0.3	3.1	- 198	322		880			
3DE69	ADIA	POSITION B					- 5.7							
31MR70	GSC	GEN Y 39 613									922			
30AP70	GSC	GEN Y 39 613									942			
7MY70	IMU	S/N 39 SHIPPED FROM GAEC TO AC/MKE.												

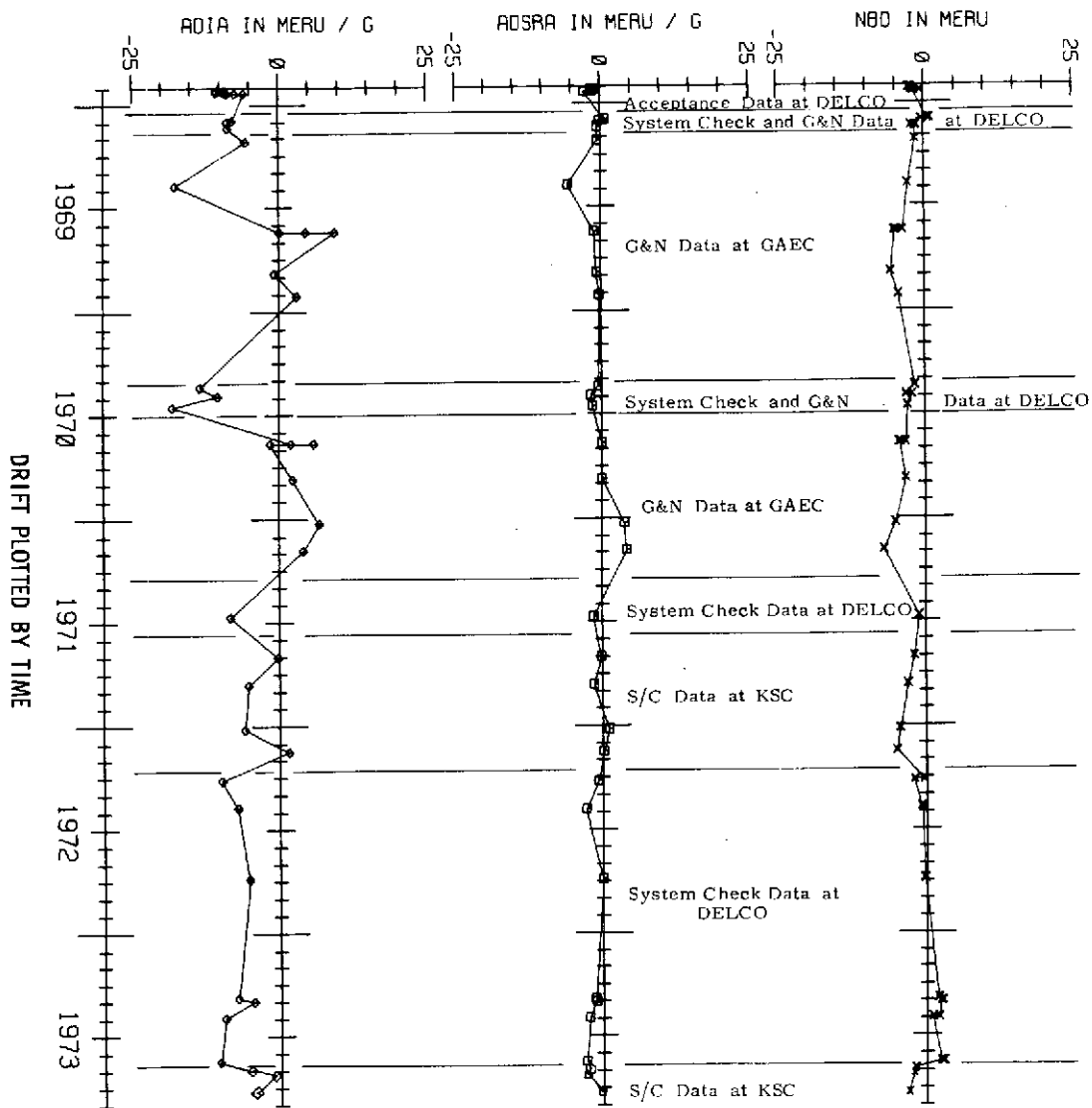
NASA RA-102

DATE	LOC	TYP	ASSN	GEN SYS	NBD	ADSFA	ADIA	DELSF+	DELSF-	WHEEL RET HOURS	I+	I-	ID	ADDA
12MY70	A05	SCR	Y 39		- 1.7		- 13.4							
12MY70	A05	SCR	Y 39		- 1.8	- 0.5				C111				1.7
12MY70	A05	SCR	Y 39							C108	973			
12MY70	NO FLUID TRANSIENTS DETECTED DURING GRAVITY TRANSIENT TEST.													
28MY70	A07	SPO	Y 39		- 3.2		- 10.4							
28MY70	A07	SPO	Y 39		- 2.2	- 1.8				C110	1016			1.2
1JE70	A07	SPO	Y 39					- 484	60		85.007			
12JE70	A07	GEN	Y 39 615					- 571	35					
16JE70	A07	GEN	Y 39 615		- 3.0	- 1.5	- 18.1				1113			
24JE70	IMU S/N 39 SHIPPED FROM AC/MKE TO GAC.													
15JL70	IMU S/N 39 INSTALLED IN LM-11 (GEN 615).													
20AU70	GSC	GEN	Y 39 615		- 3.3	0.1	2.0	- 315	261					
20AU70	ADIAI POSITION 8													
20AU70	GSC	GEN	Y 39 615		- 4.4		5.9							
20AU70	ADIAI POSITION 8													
20AU70	GSC	GEN	Y 39 615		- 4.2		1.5							
20AU70	ADIAI POSITION 8													
31AU70	GSC	GEN	Y 39 615								1156			
30SE70	GSC	GEN	Y 39 615								1177			
22OC70	GSC	GEN	Y 39 615		- 3.3	0.1	2.3	- 264	114					
22OC70	ADIAI POSITION 8													
31OC70	GSC	GEN	Y 39 615				- 10.4							
30NO70	GSC	GEN	Y 39 615								1231			
8JA71	GSC	GEN	Y 39 615		- 5.1	3.8	6.8	- 294	84		1239			
8JA71	ADIAI POSITION 8													
31JA71	GSC	GEN	Y 39 615				- 9.4							
24FE71	GSC	GEN	Y 39 615		- 7.0	4.2	4.1	- 259	186		1263			
24FE71	ADIAI POSITION 8													
28FE71	GSC	GEN	Y 39 615				- 8.4							
28FE71	ADIAI POSITION 8													
31MR71	GSC	GEN	Y 39 615								1343			
31MR71	ADIAI POSITION 8													
11AP71	GSC	GEN	Y 39 615								1355			
22AP71	IMU S/N 39 SHIPPED FROM GAC TO DELCO/MKE.													
21JE71	A07	SPO	Y 39		- 1.1		- 8.3							
21JE71	A07	SPO	Y 39		- 1.2	- 1.5								
22JE71	A07	SPO	Y 39					- 461	50	C114	85.006			1.0
25JE71	NO FLUID TRANSIENTS DETECTED DURING GRAVITY TRANSIENT TEST.													
27JL71	IMU 39 SHIPPED FROM DELCO/MKE TO KSC.													
11AU71	IMU 39 INSTALLED IN LM-11													
31AU71	KOB	GEN	Y 39 615		- 2.0	- 0.2	- 0.2	- 530	44					1.2
31AU71	ADIAI POSITION 8													
19OC71	KOB	GEN	Y 39 615		- 3.1	- 1.4	- 5.3							1.6
19OC71	ADIAI POSITION 8													
6JA72	K9A	GEN	Y 39 615		- 4.4	1.1	- 5.9	- 432	181					1.4
6JA72	ADIAI POSITION 8													
14FE72	K9A	GEN	Y 39 615		- 5.0	0.2	1.6							2.3
14FE72	ADIAI POSITION 8													
29FE72														
22MR72	IMU S/N 39 REMOVED FROM LM-11 DUE TO BAD Y-PIPA.													
23MP72	IMU S/N 39 SHIPPED FROM KSC TO DELCO/MKE.													

NASA 9A-102

DATE	LOC	TST IMU TYP ASSN	G5N SYS	NBD	ADSFA	ADIA	DELSF+	DELSF-	WHEFL RDT HOURS	I+	I-	ID	ADDA
5AP72	A07	SPO Y 39		- 0.4		- 9.8							
6AP72	A07	SPO Y 39		- 2.0	- 0.7		- 407	60		85.005			
22MY72	A07	SPO Y 39		- 0.8		- 7.1							
25MY72	A07	SPO Y 39		- 0.6	- 2.8		- 407	7		85.006			
26SE72	SB6	SPO Y 39		- 0.3		- 5.2							
26SE72	SB6	SPO Y 39		- 0.2	0.0		- 397	195		85.000			
26SE72 NO FLUID TRANSIENTS DETECTED DURING GRAVITY TEST.													
10JA73 UNIT REMOVED FROM IMU-39.													
10JA73 UNIT ASSIGNED TO IMU-34, Y-POS. REPLACES 7C033.													
10JA73									2078				
12AP73	SB6	SPO Y 34				- 7.2	- 751	- 202		84.999			
24AP73	SB6	SPO Y 34		2.0									0.3
25AP73	SB6	SPO Y 34		2.0	- 1.3								
25AP73 NO FLUID TRANSIENTS DETECTED DURING GRAVITY TEST.													
30AP73									2203				
30AP73	SB6	SPO Y 34		2.7		- 4.5							
30AP73	SB6	SPO Y 34		2.4	- 1.2				C114				
29MY73	SB6	SPO Y 34		2.0		- 9.4			C116				
29MY73	SB6	SPO Y 34		1.0	- 2.3		- 673	- 228	C113	85.000			0.1
30JE73									2363				
13AU73	SB6	SPO Y 34					- 594	- 135		85.000			
14AU73	SB6	SPO Y 34		2.5		- 10.3			C115				
15AU73	SB6	SPO Y 34		2.9	- 2.9								
21AU73 IMU-34 SHIPPED FROM DELCO TO KSC.													
24AU73 IMU-34 INSTALLED IN CM-118 (SKYLAB-4).													
28AU73	K9B	GEN Y 34 222		- 1.4	- 2.7	- 4.4	- 770	- 272					2.0
28AU73	ADIA	POSITION-8				- 7.6							
4SE73	K9B	GEN Y 34 222		- 1.8	- 2.9	- 1.3							1.7
4SE73	ADIA	POSITION-8				- 5.8							
10OC73	K9B	GEN Y 34 222		- 2.9	- 0.2	- 3.9							2.1
10OC73	ADIA	POSITION-8				- 9.7							

G&N 222, CM 118, IMU 34, APOLLO IRIG 8A102, Y AXIS



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DATE	LOC	TST IMU TYP ASSN	G&N SYS	NRD	ADSPA	ADIA	DELSE+	DELSE-	WHFFL RDT HOURS	I+	I-	ID	ADDA
19NO68	SG	84.2, 69.0, 57.3		TA	54.7, 68.8, 82.2				SEP H5202				
20NO68	A41	CSS							C104				
20NO68	A41	CSS	(10.7)	(- 0.4)	(- 3.7)				C105			12.5	
25NO68	A43	CSS	(14.3)	(- 2.4)	(- 0.5)				139			16.8	
28NO68	A42	CSS	(18.1)	(1.1)	(- 6.6)				131			20.2	
28NO68	BANK #2	CSS OOS - UNIT DEGAUSSED & CSS PERUM											
29NO68	A42	CSS	(12.6)	(- 3.7)	(0.8)				130			11.8	
30NO68	A42	CSS							126				
30NO68	A42	CSS	(11.1)	(- 3.0)	(2.7)				128			12.1	
9DE68	COMP SELECT												
9DE68	A42	CSS					72	369	135	85.002	85.002		
10DE68	COMP VERIF												
10DE68	A42	CSS					- 783	232		85.002	85.003		
10DE68	DEMO	T/F = 1196.33											
10DE68	A42	CSS					44	324	137	85.002	85.002		
10DE68	VIB	IA ALIGN = -0.5											
12DE68	A45	CA1	- 1.7		2.9	0.0							
12DE68	A45	CA2	- 1.7		2.9	0.7	144	314		85.002	85.003	11.0	
12DE68	A45	CA3	- 1.7		2.9	- 1.3			139				
15DE68	A45	CB1	- 0.9		3.1	- 3.5							
15DE68	A45	CB2	- 0.1		3.0	- 6.1	131	327		85.003	85.003	12.4	
15DE68	A45	CB3	- 0.3		2.5	- 5.0			139				
18DE68	A44	CC1	1.5		3.5	- 3.4							
18DE68	A44	CC2	2.7		3.4	- 6.0	93	317		84.989	84.990	16.2	
18DE68	A44	CC3	1.6		3.4	- 3.4			138	523			
13JA69	ACCEPTED ON WAIVERS E1415 & C1231 REV. 1												
	UNIT INSTALLED IN IMU S/N 397, REPLACING 7A-135												
28JA69	A17	SPO Z 39	2.6		10.2		451	50		85.007		1.0	
28JA69	A17	SPO Z 39	3.2		- 15.0								
30JA69	A17	SCK Z 39	2.3		10.3							1.1	
30JA69	A17	SCK Z 39	2.8		- 15.5				613				
10FE69	A17	G&N Z 39	3.7		8.0	- 13.3	242	13					
10FE69	A17	G&N Z 39	3.2										
10FE69	A17	G&N Z 39	4.0						668				
26FE69	IMU	S/N 39 SHIPPED TO GAEC											
6MR69	G20	G&N Z 39 613	1.7		6.4	- 14.4	107	- 38		692			
23MY69	G20	G&N Z 39 613	2.3		13.9	- 20.3	200	216		703			
13AU69	GSC	G&N Z 39 613	4.3		1.6	- 11.8	320	94		765			
25OC69	GSC	G&N Z 39 613	4.6		- 0.7	- 10.4	363	206		832			
3DE69	GSC	G&N Z 39 613	4.9		- 1.6	- 8.2	231	104		849			
31MR70	GSC	G&N Z 39 613								935			
30AP70	GSC	G&N Z 39 613								955			
7MY70	IMU	S/N 39 SHIPPED FROM GAEC TO AC/TKC.											
12MY70	A05	SCK Z 39	3.7		- 11.4								
13MY70	A05	SCK Z 39	4.5		5.6				C104			1.8	
13MY70	A05	SCK Z 39							C109				
13MY70	A05	SCK Z 39							C107	986			
13MY70	NO FLUID TRANSIENTS DETECTED DURING GRAVITY TRANSIENT TEST.												
28MY70	A07	SPO Z 39							C105	1029			
1JE70	A07	SPO Z 39	3.0		- 14.3								

NASA 8A-101

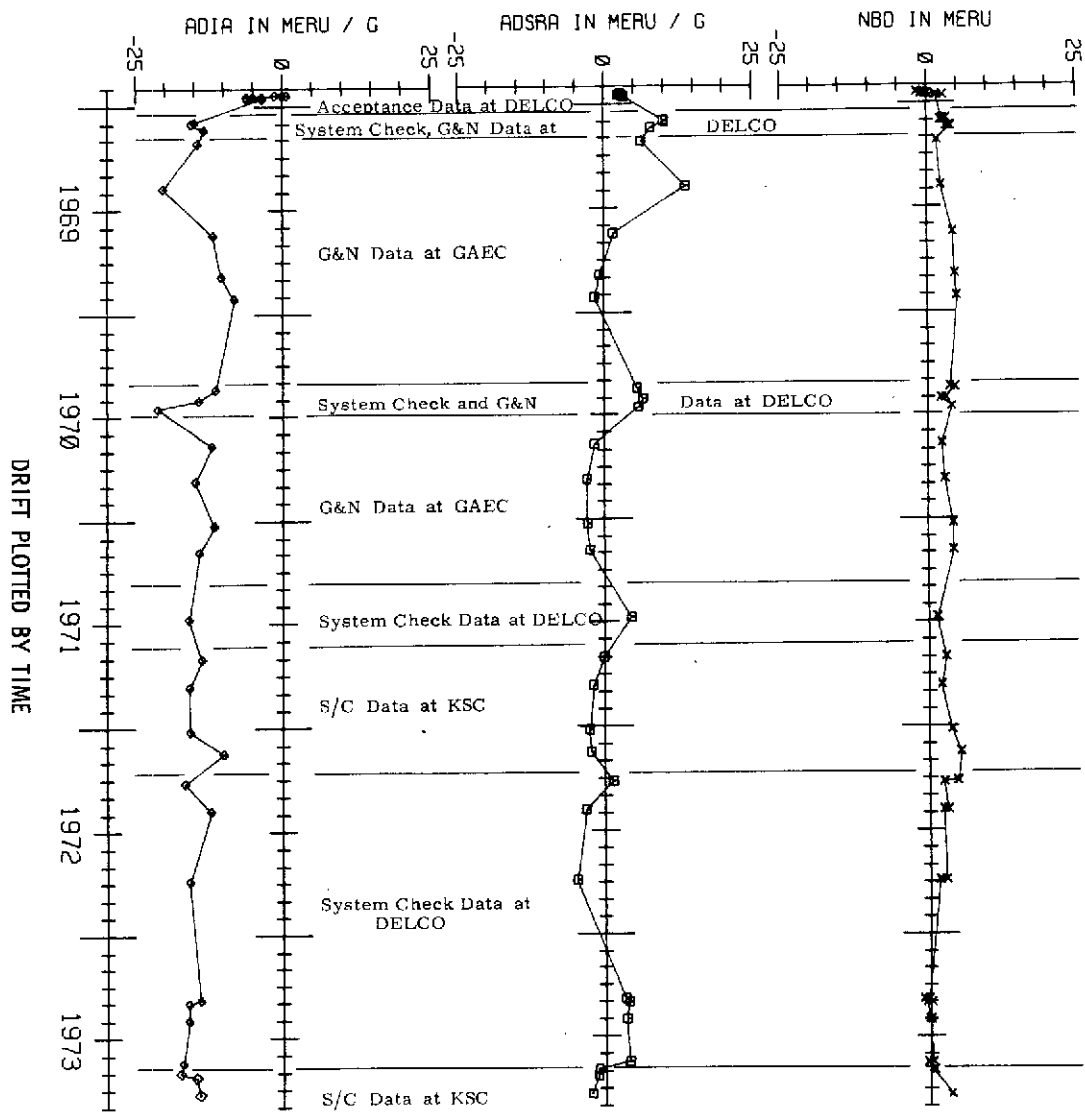
DATE	LOC	TST TYP	IMU ASSN	GEN SYS	NBD	ADSF-A	ADIA	DELSF+	DELSF-	WHEEL ROT HOURS	I+	I-	ID	ADDA	
1JE70	A07	SPO	Z	39	2.2	6.6		384	- 60		85.007			1.2	
12JF70	A07	GEN	Z	39 615				227	- 170						
16JE70	A07	GEN	Z	39 615	4.0	5.8	- 21.2			1126					
24JE70	IMU	S/N	39	SHIPPED FROM AC/MKE TO GAC.											
15JL70	IMU	S/N	39	INSTALLED IN LM-11 (GEN 615).											
20AU70	GSC	GEN	Z	39 615	2.3	- 1.7	- 12.0	341	73						
31AU70	GSC	GEN	Z	39 615						1168					
30SE70	GSC	GEN	Z	39 615						1190					
22OC70	GSC	GEN	Z	39 615	2.8	- 3.0	- 14.8	221	31						
31OC70	GSC	GEN	Z	39 615						1244					
31NO70	GSC	GEN	Z	39 615						1252					
8JA71	GSC	GEN	Z	39 615	4.2	- 2.9	- 11.6	338	38						
31JA71	GSC	GEN	Z	39 615						1276					
24FE71	GSC	GEN	Z	39 615	4.2	- 2.4	- 14.2	297	55						
28FE71	GSC	GEN	Z	39 615						1356					
31MR71	GSC	GEN	Z	39 615						1368					
11AP71	GSC	GEN	Z	39 615						1390					
22AP71	IMU	S/N	39	SHIPPED FROM GAC TO DELCO/MKE.											
22JE71	A07	SPO	Z	39	1.5	- 15.9									
22JE71	A07	SPO	Z	39	1.4	4.5		294	- 174	C113	85.006			1.7	
25JE71	NO FLUID TRANSIENTS DETECTED DURING GRAVITY TRANSIENT TEST.														
27JL71	IMU	39	SHIPPED FROM DELCO/MKE TO KSC.												
11AU71	IMU	39	INSTALLED IN LM-11												
31AU71	KOB	GEN	Z	39 615	2.9	- 0.1	- 13.7	- 66	244					1.5	
19OC71	KOB	GEN	Z	39 615	2.1	- 1.9	- 15.8							1.6	
6JA72	K9A	GEN	Z	39 615	3.8	- 2.6	- 15.7	116	513					1.4	
14FE72	K9A	GEN	Z	39 615	5.3	- 2.3	- 10.0							1.2	
29FE72															
22MR72	IMU	S/N	39	REMOVED FROM LM-11 DUE TO BAD Y-PIPA.											
23MR72	IMU	S/N	39	SHIPPED FROM KSC TO DELCO/MKE.											
5AP72	A07	SPO	Z	39	4.7	1.4									
6AP72	A07	SPO	Z	39	2.4	- 16.6		361	40		85.005				
25MY72	A07	SPO	Z	39	3.1	- 12.2									
25MY72	A07	SPO	Z	39	2.4	- 3.2		394	40		85.006				
26SE72	SB6	SPO	Z	39	2.8	- 15.8									
26SE72	SB6	SPO	Z	39	1.6	- 4.8		594	140		85.000				
26SE72	NO FLUID TRANSIENTS DETECTED DURING GRAVITY TEST.														
10JA73	UNIT REMOVED FROM IMU-39.														
10JA73	UNIT ASSIGNED TO IMU-34, Z-POS. REPLACES 7B189.														
10JA73															
13AP73	SB6	SPO	Z	34				176	- 443		84.999				
25AP73	SB6	SPO	Z	34	- 0.3	- 14.0									
25AP73	SB6	SPO	Z	34	- 1.1	3.4								- 1.8	
25AP73	NO FLUID TRANSIENTS DETECTED DURING GRAVITY TEST.														
30AP73															
1MY73	SB6	SPO	Z	34	0.2	- 16.0									
1MY73	SB6	SPO	Z	34	- 0.6	3.9				C114					
31MY73	SB6	SPO	Z	34	- 0.2	- 16.0				C111					
31MY73	SB6	SPO	Z	34	0.1	3.5		135	- 187	C112	85.000			- 2.2	
30JE73															

8A-101 CONTINUED

NASA 8A-101

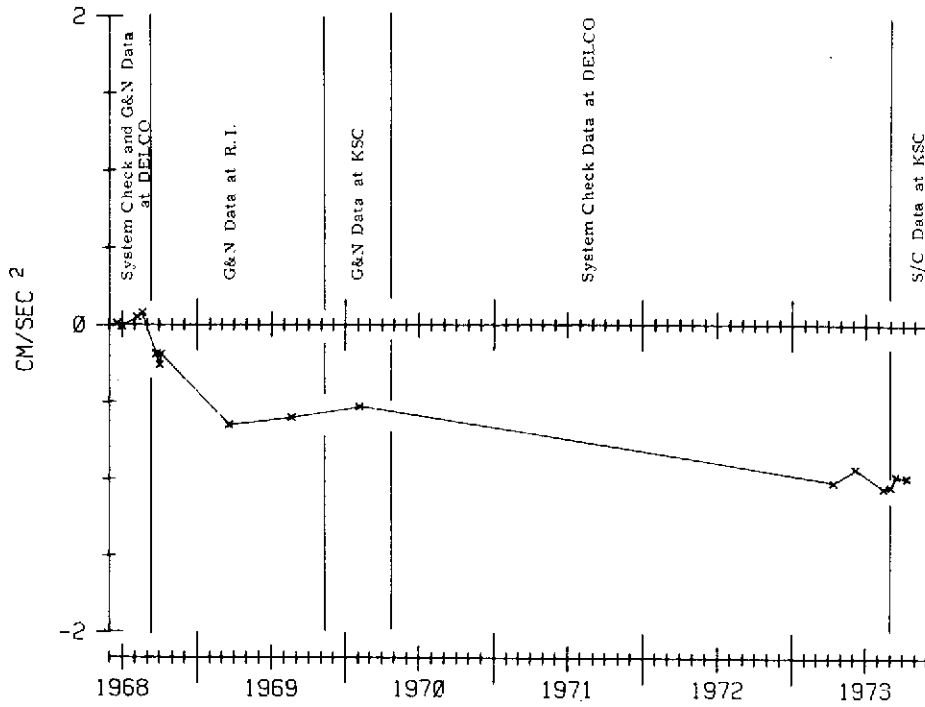
DATE	LOC	TST	IMU	GEN	ASSN	SYS	NRD	ALSPA	ADIA	DELSF+	DELSF-	WHEEL RET HOURS	I+	I-	ID	ACOA
13AU73	SB6	SPO	Z	34						250	- 121	C115	84.998			
15AU73	SB6	SPO	Z	34			0.4		- 17.0							
15AU73	SB6	SPO	Z	34			- 0.4	4.1								
21AU73	IMU-34	SHIPPED FROM DELCO TO KSC.														
24AU73	IMU-34	INSTALLED IN CM-118 (SKYLAB-4).														
28AU73	K9B	GEN	Z	34	222		0.6	- 1.0	- 17.9	- 70	- 259					1.3
4SE73	K9B	GEN	Z	34	222		1.5	- 1.1	- 14.0							1.4
10OC73	K9B	GEN	Z	34	222		2.9	- 2.0	- 12.9							1.2

G&N 222, CM 118, IMU 34, APOLLO 16 8A101, Z AXIS

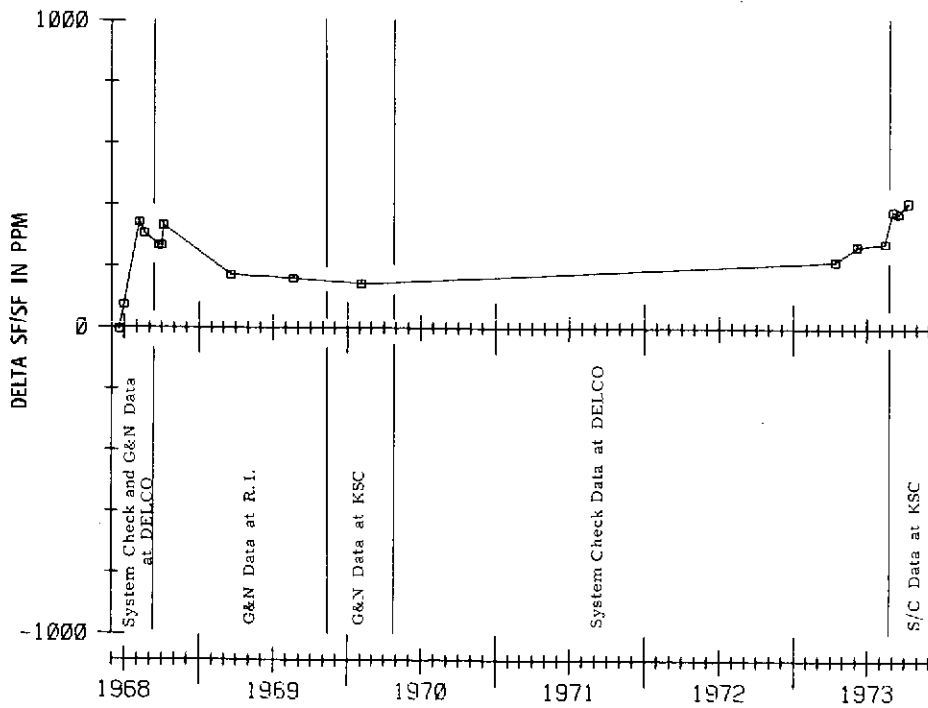


NASA 3AP-333

DATE	LOC	TST TYP	IMU ASSN	GEN SYS	DELTA SP	IG BIAS	MULL BIAS	ROT-AL-WOB ANGLE	TRANS.	TORQ MCN CURRENT
19JE67	S48	ACC			118		0.00			104.1125
13MY68	UNIT ASSN TO IMU S/N 34, X									
5JE68	A03	SPR	X 34		(458) (0.27)	(0.64)				104.1100
9JE68	A03	SPR	X 34		(- 117) (-0.93)	(-0.93)				104.1077
18JE68	A03	SPR	X 34		- 4 0.01	0.03				104.1055
18JE68	AFTER DEGAUSSING AND ADJUSTMENT									
30JE68	A03	SPO	X 34		(37) (0.88)	(0.89)				104.1065
30JE68	D CRITERIA LIMITS EXCEEDED. PIP DEGAUSSSED									
30JE68	A03	SPO	X 34		75 -0.01	-0.02				104.1068
30JE68	A03	SAL	X 34			(0.01) - 6 - 9				
31JL68	A03	SAL	X 34			(0.01) - 11 - 34				
6AD68	A07	GEN	X 34		344 0.05					
15AU68	A03	SAL	X 34			(-0.19) - 12 - 12				
19AU68	A07	GEN	X 34		308 0.08					
18SE68	IMU S/N 34 SHIPPED TO NR									
23SE68	N02	GEN	X 34 214		268 -0.19					
24SE68	N02	GAL	X 34 214			- 51 - 53				
10C68	N02	GEN	X 34 214		269 -0.26					
40C68	N02	GEN	X 34 214		334 -0.19					
19MR69	NSC	GEN	X 34 214		172 -0.65					
19AU69	NSC	GEN	X 34 214		160 -0.60					
17NO69	CM-110 SHIPPED TO KSC WITH IMU S/N 34, GEN 214 INSTALLED									
4FE70	K0B	GEN	X 34 214		144 -0.53					
27AP70	IMU S/N 34 SHIPPED FROM KSC TO MKE									
13AP73	SB6	SPO	X 34		219 -1.02	-0.98		0.04		104.0964
26AP73	SB6	SAL	X 34			(-0.88) - 11 - 4				
26AP73	SB6	SAL	X 34			(-0.90) - 18				
26AP73	SB6	SAL	X 34			(-0.92) - 19				
6JE73	SB6	SPO	X 34		269 -0.93	-0.90		0.03		104.1003
11JE73	SB6	SAL	X 34			(-0.89) - 20 - 3				
16AU73	SB6	SPO	X 34		279 -1.06	-1.06		0.03		104.0963
16AU73	SB6	SAL	X 34			(-1.04) - 19 - 7				
21AU73	IMU-34 SHIPPED FROM DELCO TO KSC.									
24AU73	IMU-34 INSTALLED IN CM-118 (SKYLAB-4).									
28AU73	K9B	GEN	X 34 222		369 -1.03					
4SE73	K9B	GEN	X 34 222		363 -0.96					
100C73	K9B	GEN	X 34 222		404 -0.98					



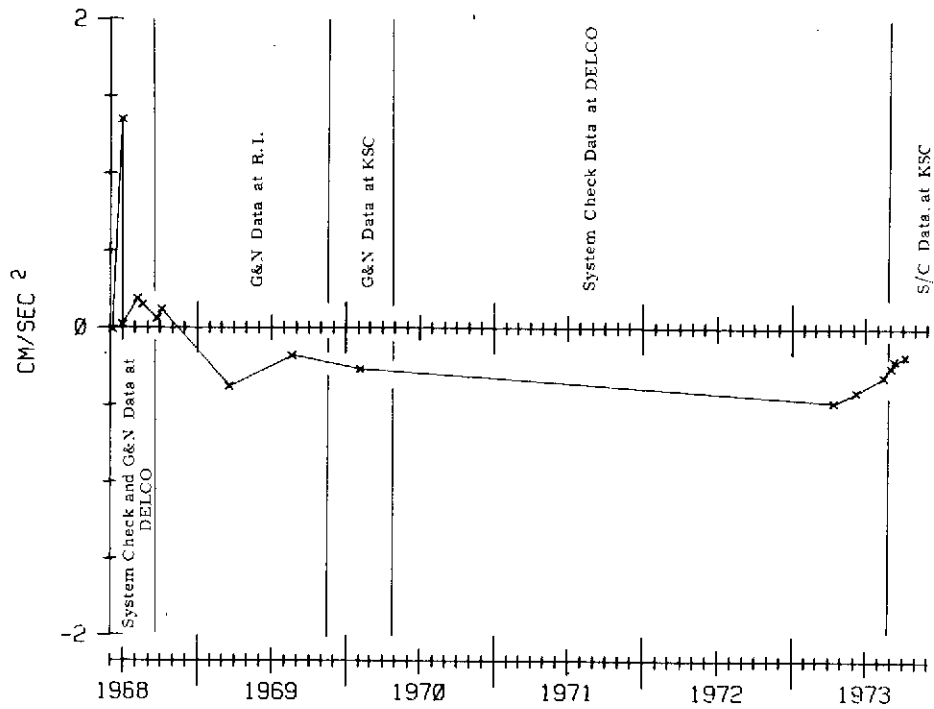
1-G BIAS DRIFT PLOTTED BY TIME



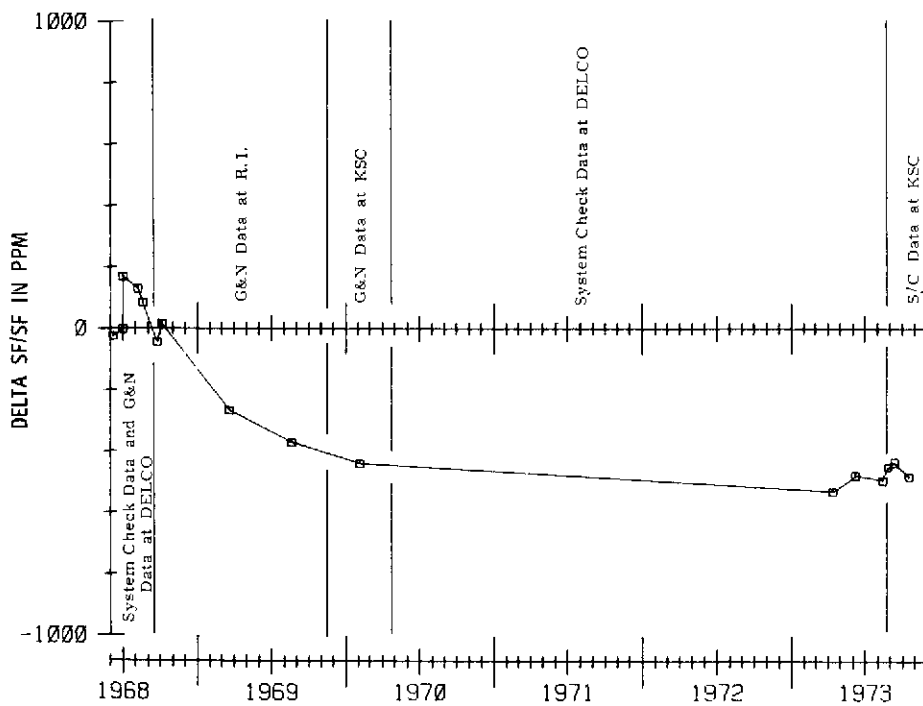
SCALE FACTOR DRIFT PLOTTED BY TIME

NASA 3AP-334

DATE	LOC	TST	IMU	G&N	DELTA	IG	NULL	ROT-AL-WOB	TRANS.	TORQ MON
		TYPE	ASSN	SYS	SP	BIAS	BIAS	ANGLE		CURPENT
23JE67	S42	ACC			- 274		0.00			104.1810
13MY68		UNIT ASSN TO IMU S/N 34, Y								
5JE68	A03	SPO Y 34			(- 196)	(0.22)	(0.21)			104.2230
6JE68	A03	SPO Y 34			- 25	-0.01	-0.09			104.2283
6JE68		AFTER DEGAUSSING AND ADJUSTMENT								
30JE68	A03	SPO Y 34			- 2	1.35	1.30			104.2275
30JE68		D CRITERIA LIMITS EXCEEDED. PIP DEGAUSSED								
30JE68	A03	SPO Y 34			168	0.02	-0.01			104.2268
30JE68	A03	SAL Y 34					(-0.05)	- 6	23	
31JL68	A03	SAL Y 34					(0.03)	0	20	
6AU68	A07	G&N Y 34			129	0.19				
15AU68	A03	SAL Y 34					(-0.14)	1	26	
19AU68	A07	G&N Y 34			83	0.15				
18SE68	IMU	S/N 34 SHIPPED TO NR								
23SE68	N02	G&N Y 34 214			- 45	0.06				
24SE68	N02	G&N Y 34 214							17	
40C68	N02	G&N Y 34 214			15	0.12				
19MR69	NSC	G&N Y 34 214			- 267	-0.38				
19AU69	NSC	G&N Y 34 214			- 371	-0.18				
17NO69	CM-110	SHIPPED TO KSC WITH IMU S/N 34, G&N 214 INSTALLED								
4PE70	K08	G&N Y 34 214			- 439	-0.27				
27AP70	IMU	S/N 34 SHIPPED FROM KSC TO MKE								
13AP73	SB6	SPO Y 34			- 531	-0.48	-0.49		0.03	104.2176
27AP73	SB6	SAL Y 34					(-0.51)	9	0	
7JE73	SB6	SPO Y 34			- 478	-0.41	-0.40		0.03	104.2201
12JE73	SB6	SAL Y 34					(-0.35)	7	26	
16AU73	SB6	SPO Y 34			- 494	-0.31	-0.32		0.05	104.2233
17AU73	SB6	SAL Y 34					(-0.33)	5	26	
21AU73	IMU-34	SHIPPED FROM DELCO TO KSC.								
24AU73	IMU-34	INSTALLED IN CM-118 (SKYLAB-4).								
28AU73	K9B	G&N Y 34 222			- 431	-0.26				
4SE73	K9B	G&N Y 34 222			- 421	-0.20				
10OC73	K9B	G&N Y 34 222			- 483	-0.18				



1-G BIAS DRIFT PLOTTED BY TIME

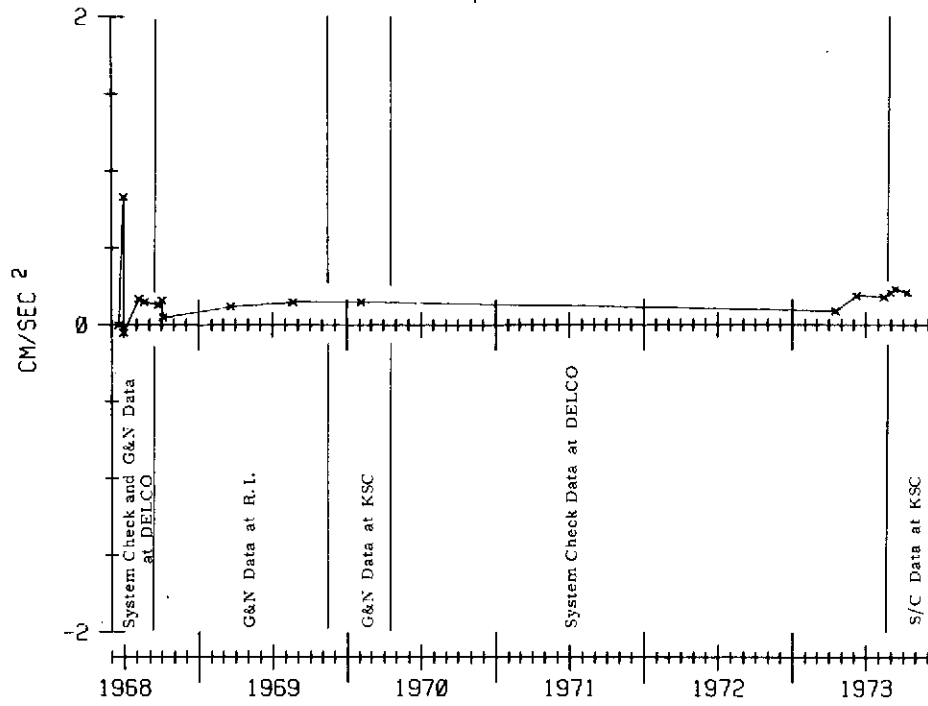


SCALE FACTOR DRIFT PLOTTED BY TIME

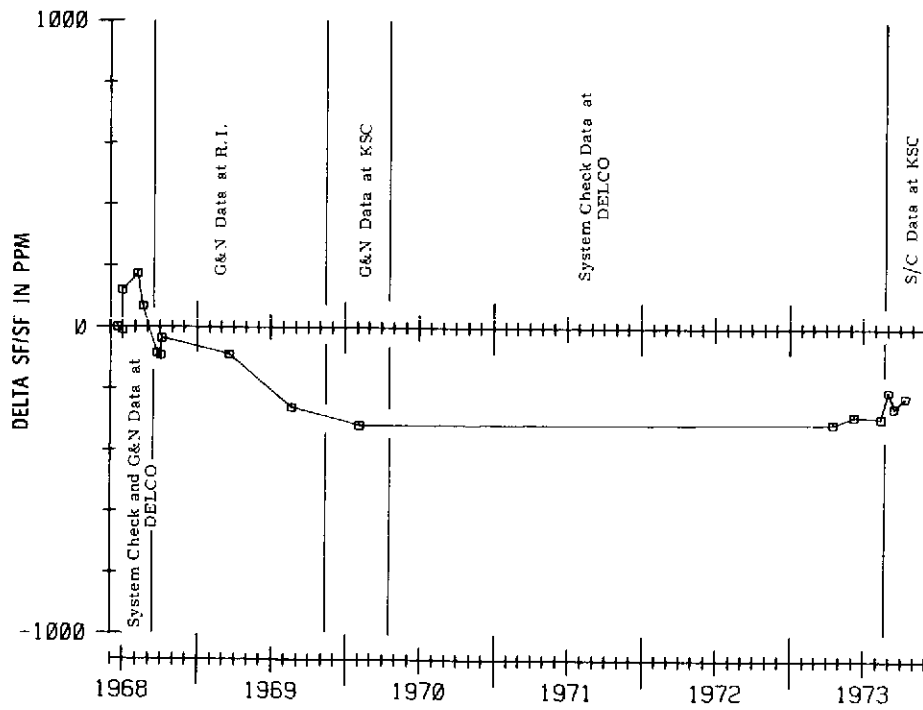
NASA 3AP-335

DATE	LOC	TST TYP	IMU ASSN	GEN SYS	DELTA SP	IS BIAS	NULL BIAS	ROT-AL-WOB ANGLE	TEAMS.	TORQ MON CURRENT
13MY68		UNIT ASSN TO IMU S/N 34, Z								
5JE68	A03	SPR	Z 34		(246)	(0.55)	(0.46)			104.0280
9JE68		RESELECT NULL/COINCIDENCE PERSISTOP								
9JE68	A03	SPR	Z 34		(253)	(-1.14)	(-1.08)			104.0340
18JE68	A03	SPR	Z 34		0	-0.00	0.07			
18JE68		AFTER DEGAUSSING AND ADJUSTMENT								
30JE68	A03	SPO	Z 34		- 10	0.83	0.86			104.0129
30JE68		D CPITERIA LIMITS EXCEEDED. PIP DEGAUSSSED								
30JE68	A03	SPO	Z 34		121	-0.05	-0.09			104.0130
30JE68	A03	SAL	Z 34				(-0.05)	- 32		
31JL68	A03	SAL	Z 34				(0.28)	- 12		
6AU68	A07	GEN	Z 34		175	0.17				
15AU68	A03	SAL	Z 34				(0.25)	- 44		
19AU68	A07	GEN	Z 34		68	0.15				
18SEP68		IMU S/N 34 SHIPPED TO NP								
23SEP68	N02	GEN	Z 34 214		- 84	0.13				
24SEP68	N02	GAL	Z 34 214					- 59 - 36		
10OC68	N02	GEN	Z 34 214		- 92	0.16				
40OC68	N02	GEN	Z 34 214		- 36	0.05				
19MR69	NSC	GEN	Z 34 214		- 88	0.12				
19AU69	NSC	GEN	Z 34 214		- 261	0.15				
17NO69		CM-110 SHIPPED TO KSC WITH IMU S/N 34, GEN 214 INSTALLED								
4FE70	K0B	GEN	Z 34 214		- 318	0.15				
27AP70		IMU S/N 34 SHIPPED FROM KSC TO MKK								
16AP73	SB6	SPO	Z 34		- 309	0.09	0.08		0.05	104.0037
27AP73	SB6	SAL	Z 34				(-0.18)	- 18		
7JE73	SB6	SPO	Z 34		- 284	0.19	0.22		0.04	104.0068
12JE73	SB6	SAL	Z 34				(0.24)	- 17		
16AU73	SB6	SPO	Z 34		- 291	0.18	0.22		0.03	104.0100
16AU73	SB6	SAL	Z 34				(0.26)	- 17		
21AU73		IMU-34 SHIPPED FROM DELCO TO KSC.								
24AU73		IMU-34 INSTALLED IN CM-118 (SKYLAB-4).								
28AU73	K9B	GEN	Z 34 222		- 205	0.20				
4SE73	K9B	GEN	Z 34 222		- 259	0.23				
10OC73	K9B	GEN	Z 34 222		- 234	0.21				

3AP-335 COMPLETED



1-G BIAS DRIFT PLOTTED BY TIME



SCALE FACTOR DRIFT PLOTTED BY TIME

STANDARD DEVIATION (1σ) OF THE IRIG AND PIPA
PARAMETER UNCERTAINTIES USED FOR
MISSION PERFORMANCE SUMMARY
CM 118 IMU S/N 34

PARAMETER

IMU Axis	<u>X</u>	<u>Y</u>	<u>Z</u>
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PIPA's

Data Compilation Period

8/28/73 - 10/10/73

Accelerometer Bias (cm/sec ²)	0.03	0.03	0.01
Scale Factor (SF/SF ppm)	5	8	22

IRIGs

Data Compilation Period

8/28/73 - 10/10/73

Bias Drift (MERU)	0.4	0.6	0.9
ADSRA (MERU/g)	0.4	1.2	0.4
ADIA (MERU/g)	3.5	1.4	2.1
ADOA (MERU/g)	0.0	0.2	0.1

Data is based upon performance in the IMU. Point-to-point stability operation is much better than the above data.

PROPOSED GYRO AND ACCELEROMETER
PERFORMANCE COMPENSATIONS

PARAMETER

IMU Axis	<u>X</u>	<u>Y</u>	<u>Z</u>
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PIPA's

Accelerometer Bias (cm/sec ²)	-0.98	-0.18	+0.21
Scale Factor (SF/SF ppm)	+400	-480	-230

IRIGs

Bias Drift (MERU)	-0.3*	-2.9	+2.9
ADSRA (MERU/g)	+5	0	-2
<u>ADIA (MERU/g)</u>	+2	-4	-13

* Compensation selected as NBD +.5

Dictionary of Terms

ACC	Acceptance Test Data
ACD	After Cooldown
ACE	A. C. Electronics (presently Delco Electronics)
ADJ	Adjusted
ADOA	Acceleration Sensitive Drift Due to Acceleration along the OA
BCSW	Binary Current Switch
BIA	Bias Adjusted
BUSS	High, Low, or Nominal Direct Current Test
CDN	Post Cooldown
CQL	Component Qualification
CRQ	Component Requalification
CRR	Retest after Minor Adjustment or Resistor Changes
CRT	Retest Data
CSS	Short Servo Test
CVR	Component Verification
DGI	Degaussed IRIG
DGS	Degaussed
F/F	Float Freedom
FST	Final Stability
GAL	Guidance & Navigation PIPA Alignment
G&N	Guidance & Navigation System Measurement
GP	Gaussed PIPAs
HBS	Hi Bus Voltage
I&A	Inspection and Acceptance
ISS	Inertial Subsystem Data
KSC	Kennedy Space Center
LBS	Lo Bus Voltage
MW	Milliwatt
NAR	North American Rockwell (presently Rockwell International, Inc.)
NBS	Nominal Bus Voltage
OOS	Out of Spec
RDT	Wheel Rundown Time, Seconds
RI	Rockwell International

APPENDIX

ELECTRICAL POWER REQUIREMENTS

This section was extracted from the MIT/IL Report E-1142 (Rev. 59) "SYSTEM STATUS REPORT". It is included in this report for convenience.

Electrical power and energy reporting is based upon the inflight spacecraft sequence of events for the Design Reference Mission as developed by the Apollo Mission Planning Task Force (AMPTF). (Reference GAEC Report Volume III - LED-540-12, dated October 30, 1964).

The accompanying diagrams present the power drawn through the spacecraft circuit breakers. It is assumed that power is drawn from the spacecraft's primary +28VDC supply and a 400 cps-115 VAC single-phase inverter.

Intermittent power peaks can exist, particularly during operation of displays and controls at random times. The energy content in these peaks is considered negligible.

All values (except those mentioned above) are actual expected levels of power at 28.0 VDC. They are based on measured values on G&N systems 207 and 208 for the Block II Command Module. No margin factor has been applied to protect against possible differences between G&N systems and spacecrafts. Thus, these values should not be taken as "not to exceed" extremes.

The following Interface Control Documents serve as the guidelines for reporting power figures.

CM Block II MH01-01327-216 "G&N Electrical Input Power" signed 15 July 1965.

BLOCK II GUIDANCE & NAVIGATION LOAD ON PRIMARY +28 VDC COMMAND MODULE

BASED UPON 198.5 HOURS (18.27 DAY) LUNAR ORBIT MISSION
DESIGN REFERENCE MISSION

STATUS OCTOBER 1967

REFERENCE GAC REPORT - LED 540-12, 30 OCTOBER 1964
APOLLO MISSION PLANNING TASK FORCE

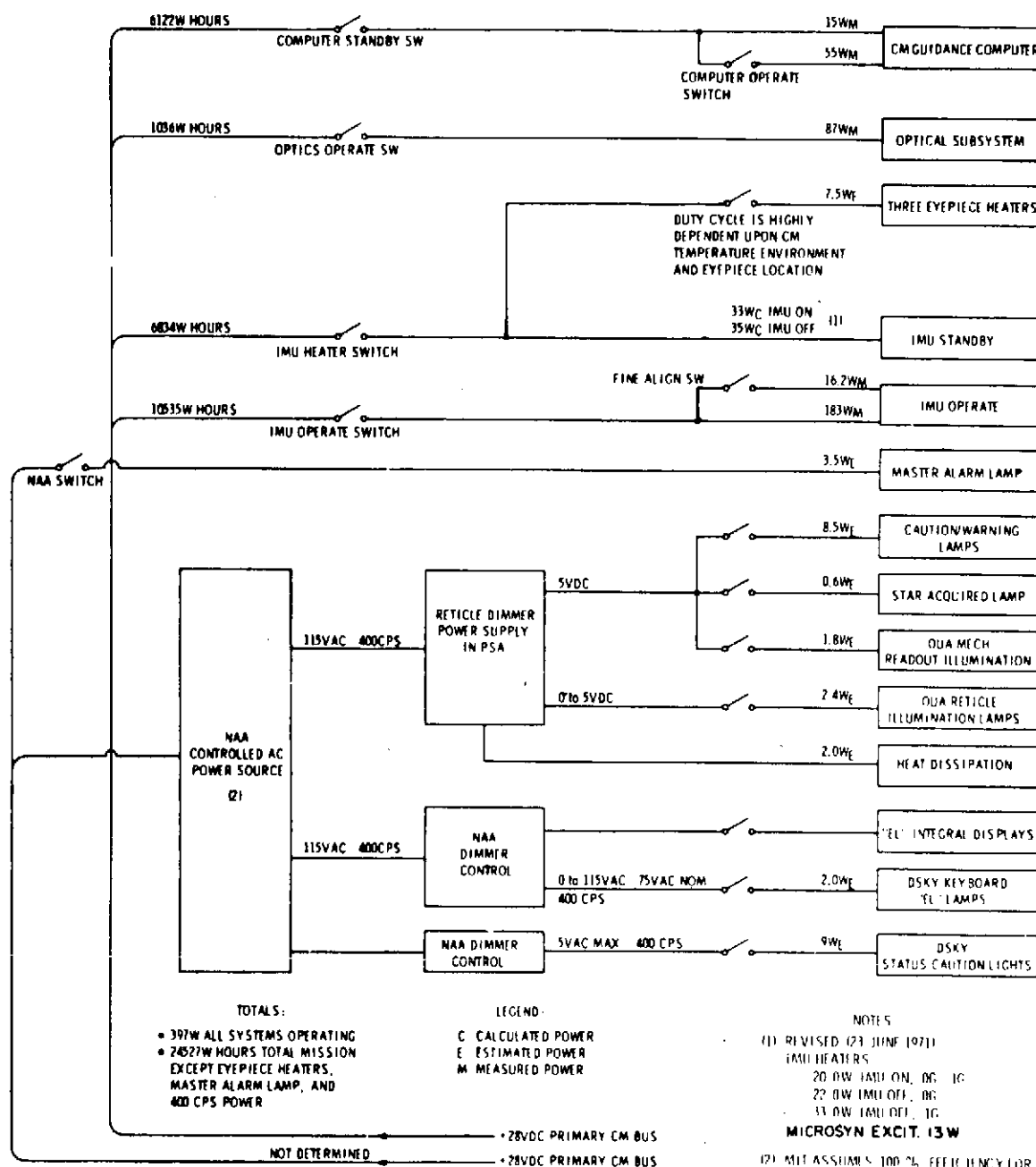


Figure A-1